Synopsis of Predation on Juvenile Chinook Salmon by Predatory Fishes in the Cedar River, south Lake Washington, and the Ship Canal

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Summary

Previous predator sampling of the Lake Washington system focused on predation of sockeye salmon *(Oncorhynchus nerka)* and little effort was given to quantify predation of Chinook salmon *(O. tshawytscha)*. In 1999 and 2000, we sampled various fish species to better understand the effect that predation has on Chinook salmon populations. Additionally, we reviewed existing data to get a more complete picture of predation. Consumption estimates were greatly improved with the results of genetic analysis, which allowed us to determine which salmonid species were consumed. We collected predators in three areas of the Lake Washington basin where juvenile Chinook salmon may be particularly vulnerable to predatory fishes. Two of these areas, the Cedar River and the south end of Lake Washington are important rearing areas. In these areas, Chinook salmon may be vulnerable because they are small and are present for a relatively long period of time. The other study area, Lake Washington Ship Canal (LWSC; includes Portage Bay, Lake Union, Fremont Cut, and Salmon Bay), is a narrow migratory corridor where Chinook salmon smolts are concentrated during their emigration to Puget Sound.

Cedar River.– Within the Lake Washington basin, an important, wild run of Chinook salmon occurs in the Cedar River. Juvenile Chinook salmon are present in the Cedar River from January to July. Juvenile Chinook salmon appear to have two rearing strategies: 1) rear in the river and then emigrate to the lake in May or June as a presmolt, and 2) emigrate to the lake as fry in January, February or March and rear in the lake for several months. Both groups then emigrate as smolts to Puget Sound in June or July. The main objectives of this study were to identify important fish predators of juvenile Chinook salmon, estimate total predation by these predators, and begin to understand the spatial and temporal variation in predation.

In 2000, we examined the stomach contents of 599 fish and only 8 juvenile Chinook salmon were found. Most predation was by large rainbow trout *(O. mykiss)*. Predation occurred primarily in large, deep pools ("primary" pools). Because Chinook salmon do not appear to use primary pools as rearing habitat and they must move through these pools when they emigrate downstream, we assumed that predation may occur during this time when they are moving downstream. Thus, there may be some degree of risk in emigrating to the lake as fry. Using a habitat-based model, our estimate of the total predation of Chinook salmon was 24,000 fish, which would be approximately 27% of the natural Chinook salmon production in the Cedar River.

We also reviewed additional data collected in 1995-2000. A consumption estimate was also made for 1998 when we sampled throughout the river. In 1998, predation was observed in secondary pools (small main channel pools and side-channel pools) as well as primary pools. Most of the incidence of predation was observed in stomach samples of cutthroat trout *(O. clarki)* and torrent sculpin *(Cottus rhotheus)*. Most predator sampling in May and June was conducted in the lower 1.7 km of the river as part of the lower Cedar River flood control project. Out of 177 large salmonids and 119 large cottids, only one Chinook salmon was found in the stomach samples; a 238 mm forklength (FL) cutthroat trout had consumed a 88 mm FL Chinook salmon.

South End of Lake Washington.– Once Chinook salmon enter Lake Washington, they inhabit shallow water less a meter deep (January to mid May) and are concentrated in the south end of the lake near the mouth of the Cedar River. To better understand the effect that predators have on the survival of Chinook salmon, we reviewed existing information from 1995-1997 that originally focused on sockeye salmon predation. Nearshore predators were collected from February to June, primarily with electrofishing equipment. In the three years combined, we examined the stomach contents of 1,875 fish. A total of only 15 Chinook salmon were found. The only predators observed to consume Chinook salmon were cutthroat trout, prickly sculpin (*C. asper*), smallmouth bass (*Micropterus dolomieui*)**,** and largemouth bass (*M. salmoides*). Consumption of Chinook salmon by cutthroat trout was observed in February, March and early April. Predation by prickly sculpin was only observed in February. Smallmouth bass consumed Chinook salmon in May and June. Few largemouth bass were collected; however, we did document a largemouth bass that had consumed a Chinook salmon in June. We estimated a total of 1,400 Chinook salmon fry were consumed by littoral predators from February to mid May. Most of the predation loss was attributed to prickly sculpin, who had a substantially larger population size than the other predators. Based on consumption estimates and expected abundance of juvenile Chinook salmon, predatory fishes probably consumed less than 10% of the fry that entered the lake from the Cedar River.

Lake Washington Ship Canal.– In the Lake Washington basin, salmonid smolts must migrate through the Lake Washington Ship Canal (LWSC; includes Montlake Cut, Portage Bay, Lake Union, Fremont Cut, and Salmon Bay) and pass through the Ballard Locks before they reach the marine environment. Within the LWSC, smolts are vulnerable to several species of predatory fishes, including northern pikeminnow (*Ptychocheilus oregonensis*), smallmouth bass, and largemouth bass. Preliminary research done by the Muckleshoot Indian Tribe, U.S. Fish and Wildlife Service, and University of Washington (UW) in 1995 and 1997 indicated that smallmouth bass may be an important predator of salmonid smolts in the LWSC. Sampling was limited to a few dates and many areas of the LWSC were not sampled. In 1999, we conducted a more intensive study to determine the overall consumption of smolts by littoral predators in the LWSC.

Fish were collected at night with boat electrofishing equipment. Stomach contents were removed and fish were tagged for a mark-recapture population estimate. Catch rates of northern pikeminnow were low in comparison to bass. This may be due to

their vulnerability to shoreline electrofishing. In other systems, northern pikeminnow appear to inhabit deeper waters than bass. From the end of April to the end of July, we removed the stomach contents of over 900 predators. Consumption of smolts was observed in both bass species and northern pikeminnow from mid-May to the end of July. Predators were collected throughout the sample area, however, few predators were collected in Salmon Bay.

Smallmouth bass of all size categories consumed salmonids. The smallest smallmouth bass observed to have consumed a salmonid was 138 mm fork length (FL). Predation appeared to be highest in June, when salmonids made up approximately 50% of their diet. Consumption rates of salmonids by largemouth bass were generally low. Predation of Chinook salmon was only observed in fish 148-249 mm FL. Approximately 45% of the diet of northern pikeminnow consisted of salmonids. Identification of smolts was done visually for freshly ingested smolts and by genetic analysis for more digested fish. We identified 90% of all ingested salmonids to species. Of those, 45% were Chinook salmon smolts. The remainder was coho salmon (*O. kisutch*) (40%) and sockeye salmon (15%). Based on the length of ingested salmonids, littoral predators appear to prey mostly on subyearling fish. Even coho salmon and sockeye salmon appeared to be mostly subyearling fish. Coho salmon were likely hatchery fish that were released from the UW Hatchery.

Population estimates were calculated for smallmouth bass and largemouth bass. We estimated there were approximately 3,400 smallmouth bass and 2,500 largemouth bass in the LWSC. Estimates were made for fish that were > 130 mm FL which should include all fish that may consume smolts. A bioenergetics model and a direct meal-turnover model was used to estimate total consumption of smolts. The bioenergetics model predicted smallmouth bass consumed 27,300 salmonids and largemouth bass consumed 8,700. The direct meal-turnover model predicted smallmouth bass consumed 41,100 salmonids and largemouth bass consumed 4,600. The highest consumption occurred in age 2 fish because of their large population size and high growth rates. Incorporating the results of both models, smallmouth bass appeared to consume equal numbers of the three salmonid species. Largemouth bass appeared to consume mostly sockeye salmon and coho salmon and few Chinook salmon. The main salmonid consumed by northern pikeminnow was Chinook salmon (47%), followed by coho salmon (32%) and sockeye salmon (21%).

The abundance of Chinook salmon that migrated through the LWSC in 1999 is unknown. However, if we assume a 50% survival rate of hatchery Chinook salmon from Issaquah Hatchery to LWSC, then approximately 1% of the Chinook salmon would be consumed by smallmouth bass and largemouth bass, combined. No population estimate was made for northern pikeminnow, but because salmonids made up a substantial portion of their diet, they have the potential to be a significant predator if their population size in LWSC is large.